

Contract NAS10-8676

LAUNCH SITE PROCESSING OF HAZARDOUS PAYLOADS

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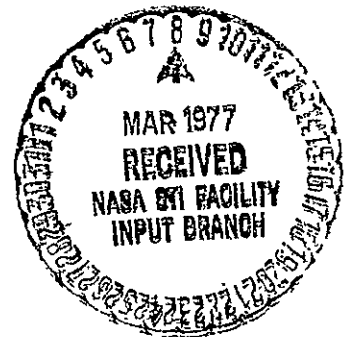
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FINAL REPORT

VOLUME 5

CURRENT PAYLOADS SURVEY AND ANALYSIS

MAY 1975



TELEDYNE
BROWN ENGINEERING

Cummings Research Park • Huntsville, Alabama 35807

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MAY 1975

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FOREWORD

This document constitutes Volume 5 of a seven-volume Final Report prepared by Teledyne Brown Engineering, Huntsville, Alabama, under NASA Contract No. NAS10-8676, Launch Site Processing of Hazardous Payloads. This study required a thorough analysis of the impact on the launch site and its operations by hazardous Space Shuttle payloads.

The seven volumes of the Final Report are as follows:

Volume 1. EXECUTIVE SUMMARY: This volume presents a concise review of the results of the study tasks and summarizes the principal conclusions and recommendations of the study.

Volume 2. HAZARDOUS PAYLOADS SURVEY AND ANALYSIS: This volume presents the results of a survey and an analysis of proposed Shuttle payloads to identify hazardous payloads and to define the characteristics of materials and systems that make them hazardous. This task included the development of a hazardous payloads ranking technique and recommendations for processing analysis on selected payloads.

Volume 3. NORMAL PROCESSING ANALYSIS: This volume presents preliminary normal processing flow plans for three Shuttle cargoes selected as a result of the Hazardous Payloads Survey and Analysis Task:

- Spacelab with Advanced Technology Laboratory
- Tug, Solar Electric Propulsion Stage, and Synchronous Earth Observatory Satellite
- Interim Upper Stage, and a Pioneer Jupiter Probe with a Fluorine Propulsion Unit

The preliminary processing flow plans include identification of unique facilities and GSE, processing hazards, and payload safety related design criteria.

Volume 4. CONTINGENCY PROCESSING ANALYSIS: This volume presents preliminary alternate processing flow plans for contingency situations for the three Shuttle cargoes analyzed in the Normal Processing Analysis Task.

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Volume 5. CURRENT PAYLOADS SURVEY AND ANALYSIS:

This volume presents the results of a survey and an analysis to determine payloads that are currently flying and that may also fly on the Shuttle vehicle when it becomes operational. The analysis determines hazardous materials/systems for each of these current payloads and recommends design and operational safety criteria for each hazardous current payload to minimize its impact on the Shuttle Transportation System. †

Volume 6. ENVIRONMENTAL IMPACT STATEMENT

POTENTIAL REQUIREMENTS: This volume presents the results of an evaluation of the probable environmental impact of Shuttle payloads hazardous materials and includes recommended KSC Environmental Impact Statement Potential Requirements.

Volume 7. ADVANCED TECHNOLOGY REQUIREMENTS:

This volume presents a list of special problems identified in the study that require advanced technology study or technology development.

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1.0 INTRODUCTION

Payloads containing hazardous materials associated with space vehicle launch operations have been recognized and dealt with on previous R&D space programs. However, when compared to the Shuttle Program, these R&D space programs involved relatively few launches with considerable time between launches. The Shuttle operational program will have a high launch rate and in many cases individual launches will have several independent payloads for accomplishment of separate missions. Some of these payloads by intent will be recoverable for purpose of reuse, and all must be recoverable in the sense that possible abort situations prior to deployment have to be recognized.

Present processing schedules have been derived assuming nominal passive payloads and nominal payload flow time. A number of specifically safety oriented studies on Shuttle payloads have been performed in recent years. However, relatively few of these have treated ground operations in depth, and the overall impact of Shuttle payload hazards on launch and landing site processing and procedures has not been documented. In order to fill this gap, this ten month study was initiated in July 1974. The overall study objectives were to uncover and determine the hazard potential of Shuttle payloads, develop safety oriented normal and contingency launch site processing plans for selected cargoes that will minimize the impact on cost and schedules, and provide for environmental protection.

1.1 TASK OBJECTIVES

The objective of this task is to determine and recommend design and operational safety criteria that should be applied to hazardous systems of current payloads (flown on unmanned vehicles) that may eventually fly on the Space Shuttle.

1.2 SCOPE

The scope of this task includes determining those payloads that are currently flying or are planned to fly on unmanned vehicles before the Shuttle Transportation System (STS) becomes operational and that may be flown on the STS. The hazardous materials and systems are to be determined for the payloads that fall into this classification (Current Payloads). Design and operational safety criteria are to be developed for each current payload hazardous material or system to minimize its impact on the STS, launch processing, facilities, time, and cost.

1.3 TASK APPROACH

The first step in this task was to identify current payloads that are candidates for flight on the Space Shuttle. The most all inclusive data source for candidate Shuttle payloads was the Level A Summarized NASA Payloads Descriptions of Automated Payloads, July 1974. Since this document only covers planned Shuttle payloads from 1979 forward, additional data sources were necessary to identify STS candidates. The October 1973 NASA Payloads Model and the July 1973 Space Shuttle Traffic Model documents, which cover payload flights from 1973 forward, were used to determine the current payloads.

Using data obtained from these documents and contacts with the scientific community, an analysis was performed to determine the hazardous materials and systems associated with these payloads.

Applicable design and operational safety criteria were then developed from the findings of our normal and contingency processing analysis tasks, available safety studies, and other sources, such as NASA Safety Requirements established for payloads to be flown on the STS. These safety criteria were grouped according to the type or category of hazardous system or element.

The safety criteria applicable to each of the identified current payloads were specified. These safety criteria provide a checklist for evaluating the design adequacy from a safety standpoint for those current payloads that are candidates for flight on the Shuttle Orbiter. A schematic outline of this safety criteria development process is presented in Figure 1.

1.4 SUMMARY OF RESULTS

The payloads listed in Figure 2 are considered current payloads because they have flown or are scheduled to fly between 1973 and 1980 and are scheduled to fly during the planned operational phase of the STS. The applicable design and operational safety criteria are shown for each current payload.

With the exception of Mini-LAGEOS (OP-03-A) payload, all current payloads contain hazardous materials or systems. The Mini-LAGEOS payload is a passive spherical reflector structure and contains no hazardous materials or systems. The remaining 20 current payloads

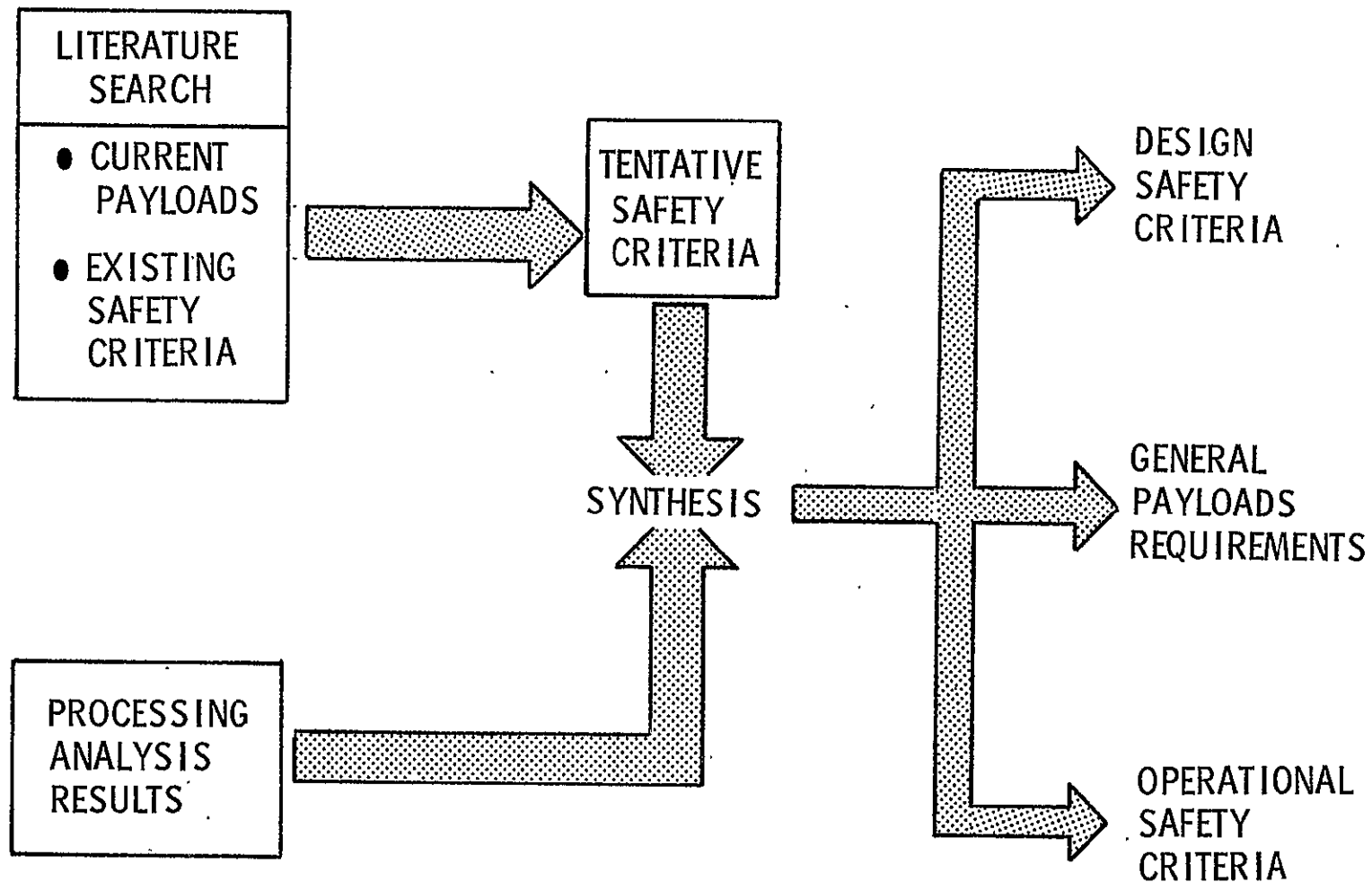


FIGURE 1. SAFETY CRITERIA DEVELOPMENT

APPLICABLE SAFETY CRITERIA FOR CURRENT PAYLOADS		APPLICABLE SAFETY CRITERIA					
APPLICABLE STS PAYLOAD CODE	CURRENT PAYLOADS	TOXIC FLUIDS / GASES OPERATIONAL	LIQUID / GAS PROPULSION DESIGN & OPERATIONAL	PYROTECHNICS & SOLID PROPELLANT DESIGN & OPERATIONAL	ELECTRICAL DESIGN & OPERATIONAL	RTG DESIGN & OPERATIONAL	GENERAL
	PAYLOAD NAME						
AS-02-A	Extra Coronal Lyman Alpha Explorer		X	X	X		X
AS-03-A	Cosmic Background Explorer		X	X	X		X
EO-07-A	Advanced Synchronous Meteorological Satellite	X	X		X		X
EO-08-A	Earth Observatory Satellite	X	X	X	X		X
EO-10-A	Applications Explorer (Special Purpose Satellite)	X	X	X	X		X
EO-12-A	TIROS 'O'	X	X	X	X		X
EO-56-A	Environmental Monitoring Satellite	X	X	X	X		X
EO-57-A	Foreign Synchronous Meteorological Satellite	X	X		X		X
EO-58-A	Geosynchronous Operational Meteorological Satellite	X	X		X		X
EO-61-A	Earth Resources Survey Operational Satellite	X	X	X	X		X
OP-01-A	GEOPAUSE		X		X		X
OP-02-A	Gravity Gadiometer		X		X		X
OP-03-A	Mini-LAGEOS						
OP-07-A	SEASAT-B	X	X	X	X		X
PL-22-A	Pioneer Saturn Probe	X	X	X	X	X	X
CN-51-A	INTERSAT	X	X	X	X		X
CN-52-A	U. S. DOMSAT 'A'	X	X	X	X		X
CN-53-A	U. S. DOMSAT 'B'	X	X	X	X		X
CN-55-A	Traffic Management Satellite	X	X	X	X		X
CN-56-A	Foreign Communications Satellite A	X	X	X	X		X
CN-58-A	U. S. DOMSAT 'C'	X	X	X	X		X

FIGURE 2. APPLICABLE SAFETY CRITERIA FOR CURRENT PAYLOADS

contain hazardous materials or systems. All the hazardous materials and systems contained in the current payloads have been processed at KSC in the past. An in-depth design analysis of each of the final designs of these current payloads would be required to properly assess the degree to which the recommended safety criteria should be applied.

The applicable safety criteria for each of these current payloads give NASA a checklist to evaluate how successful the payload designer was in eliminating or reducing the hazards to the STS stemming from the hazardous materials and systems on these payloads.

2.0 CURRENT PAYLOADS & HAZARD IDENTIFICATION

2.1 CURRENT PAYLOADS SURVEY AND IDENTIFICATION

This survey covered the following payloads that are grouped by Scientific Discipline and cover space opportunities from 1973 through 1991. The payloads selected for analysis were those freeflying units that have flown in 1973 or later and are scheduled for flight after the STS becomes operational in 1980. The most inclusive source located was the Level A Summarized NASA Payloads Descriptions of Automated Payloads, July 1974. The sources selected to determine approved and ongoing as well as planned flights were the October 1973 NASA Payloads Model and the July 1973 Space Shuttle Traffic Model documents.

ASTRONOMY

AS-01-A	Large Space Telescope
*AS-02-A	Extra Coronal Lyman Alpha Explorer
*AS-03-A	Cosmic Background Explorer
AS-05-A	Advanced Radio Explorer
AS-07-A	3m Ambient Temperature IR Telescope
AS-11-A	1.5m IR Telescope
AS-13-A	UV Survey Telescope
AS-14-A	1.0m UV-Optical Telescope
AS-16-A	Large Radio Observatory Array (LROA)
AS-17-A	30m IR Interferometer

HIGH ENERGY ASTROPHYSICS

HE-01-A	Large X-Ray Telescope Facility
HE-03-A	Extended X-Ray Survey
HE-05-A	High Latitude Cosmic Ray Survey
HE-07-A	Small High Energy Satellite
HE-08-A	Large High Energy Observatory A (Gamma Ray)
HE-09-A	Large High Energy Observatory B (Magnetic Spectrometer)
HE-10-A	Large High Energy Observatory C (Nuclear Calorimeter)
HE-11-A	Large High Energy Observatory D (1.2m X-Ray Telescope)
HE-12-A	Cosmic Ray Laboratory

*Current Payload

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SOLAR PHYSICS

SO-02-A Large Solar Observatory
SO-03-A Solar Maximum Mission

ATMOSPHERIC AND SPACE PHYSICS

AP-01-A Upper Atmosphere Explorer
AP-02-A Medium Altitude Explorer
AP-03-A High Altitude Explorer
AP-04-A Gravity and Relativity Satellite - LEO
AP-05-A Environmental Perturbation Satellite - Mission A
AP-06-A Gravity and Relativity Satellite - Solar
AP-07-A Environmental Perturbation Satellite - Mission B
AP-08-A Heliocentric and Interstellar Spacecraft

EARTH OBSERVATIONS

*EO-07-A Advanced Synchronous Meteorological Satellite
*EO-08-A Earth Observatory Satellite
EO-09-A Synchronous Earth Observatory Satellite
*EO-10-A Applications Explorer (Special Purpose Satellite)
*EO-12-A TIROS 'O'
*EO-56-A Environmental Monitoring Satellite
*EO-57-A Foreign Synchronous Meteorological Satellite
*EO-58-A Geosynchronous Operational Meteorological
 Satellite
EO-59-A Geosynchronous Earth Resources Satellite
*EO-61-A Earth Resources Survey Operational Satellite
EO-62-A Foreign Synchronous Earth Observatory Satellite

EARTH AND OCEAN PHYSICS

*OP-01-A GEOPAUSE
*OP-02-A Gravity Gradiometer
*OP-03-A Mini-LAGEOS
OP-04-A GRAVSAT
OP-05-A Vector Magnetometer Satellite
OP-06-A Magnetic Field Monitor Satellite
*OP-07-A SEASAT-B
OP-51-A Global Earth & Ocean Monitor System

*Current Payload

SPACE PROCESSING APPLICATIONS

SP-01-A Space Processing Free-Flyer

LIFE SCIENCES

LS-02-A Biomedical Experiment Scientific Satellite

SPACE TECHNOLOGY

ST-01-A Long Duration Exposure Facility

PLANETARY

PL-01-A Mars Surface Sample Return
PL-02-A Mars Satellite Sample Return
PL-03-A Pioneer Venus Multiprobe
PL-07-A Venus Orbital Imaging Radar
PL-08-A Venus Buoyancy Probe
PL-09-A Mercury Orbiter
PL-10-A Venus Large Lander
PL-11-A Pioneer Saturn/Uranus Flyby
PL-12-A Mariner Jupiter Orbiter
PL-13-A Pioneer Jupiter Probe
PL-14-A Saturn Orbiter
PL-15-A Uranus Probe/Neptune Flyby
PL-16-A Ganymede Orbiter/Lander
PL-18-A Encke Rendezvous
PL-19-A Halley Comet Flyby
PL-20-A Asteroid Rendezvous
*PL-22-A Pioneer Saturn Probe

COMMUNICATIONS/NAVIGATION

*CN-51-A INTERSAT
*CN-52-A U. S. DOMSAT 'A'
*CN-53-A U. S. DOMSAT 'B'
CN-54-A Disaster Warning Satellite
*CN-55-A Traffic Management Satellite
*CN-56-A Foreign Communications Satellite A
*CN-58-A U. S. DOMSAT 'C'
CN-59-A Communications R&D/Prototype Satellite
CN-60-A Foreign Communications Satellite B

*Current Payload

LUNAR

LU-01-A	Lunar Orbiter
LU-02-A	Lunar Rover
LU-03-A	Lunar Halo Satellite
LU-04-A	Lunar Sample Return

2.2 HAZARDOUS SYSTEMS IDENTIFICATION AND CLASSIFICATION

Each payload classified as a current payload was analyzed to determine its hazardous systems and materials. This analysis was performed as part of the Hazardous Payloads Survey and Analysis Task that is included in Volume 2. The results of this analysis for the 21 current payloads are included in Section 4.0.

The hazardous materials and systems contained in the current payloads were grouped into six categories. The individual categories were established based on similarity of design features, similarity of hazardous effects, similarity in operational precautions, and convenience in assembling safety criteria:

- Radioisotope Thermoelectric Generator
- Electrical
- Pyrotechnics and Solid Propellant Motors
- Liquid/Gas Propulsion
- Toxic Fluids/Gases
- General.

3.0 SAFETY CRITERIA DEVELOPMENT

A literature search was made to locate information, reports, studies, etc., that could tentatively have an applicability to the identified current payloads. Those sources pertinent to the problem are shown in Section 3.1. Requirements, guidelines, ground rules, and criteria were extracted from these volumes based on their cursory application to the current payloads. That is, the current payloads hazard types were compared or matched to the source information, and those considered relevant were compiled into a tentative safety criteria package.

From the normal and contingency processing analysis and the hazards analysis (Volumes 3 and 4), a set of basic facility and operational and design requirements was derived for the three cargoes analyzed.

The tentative safety criteria derived from matching the current payloads against the safety literature was further matched against the safety requirements for the three cargoes. This was a process of synthesizing a new and more germane set of criteria that bears direct applicability to current payloads. The information or criteria that were considered not to apply to the current payloads hazard types were disregarded in the final set of criteria. Applicable criteria were separated into three groups:

- Design Safety Criteria
- Operational Safety Criteria
- General Payloads Safety Criteria.

The first two groups were further separated into the following:

- Radioisotope Thermoelectric Generator
- Electrical
- Pyrotechnics
- Liquid/Gas Propulsion and Auxiliary Propulsion Equipment
- Toxic Fluids/Gases.

The third group, General Payloads Safety Criteria, is not hazard-type oriented like the design and operational safety criteria but is applicable to payloads.

3.1 SAFETY CRITERIA SURVEY

A review of available safety oriented documents and reports was conducted to evaluate the extent of their applicability in developing design and operational safety criteria for current payloads to be flown on the STS. Some of the documents reviewed are:

- Safety Policy and Requirements for Payloads Using the National Space Transportation System Prepared by Payload Safety Steering Group - NASA Headquarters, Code MQ
- Kennedy Space Center General Safety Plan, Kennedy Space Center - KMI 1710.1B/SF
- Kennedy Space Center Safety Practices Handbook Kennedy Space Center - KHB 1710.2/SF
- Range Safety Manual - Volume I Headquarters, Air Force Eastern Test Range AFETRM 127-1
- Radiation Protection Handbook Kennedy Space Center - KHB 1860.1/IS
- Feasibility of Space Disposal of Radioactive Nuclear Waste Volume I and II - Lewis Research Center NASA TM X-2911 and X-2912
- Recording and Cataloging Hazards Information - Revision A - Marshall Space Flight Center - NASA TM X-64782
- Manned Space Flight Nuclear Systems Safety Volumes IV & V - General Electric - 72SD4201-1, Contract No. NAS8-26283
- Shuttle Payload Ground Operations Safety Handbook TRW Contract No. NAS10-8583
- Safety in Earth Orbit Study - Volumes I, II and V North American Rockwell - SD72-SA-0094 Contract No. NAS9-12004

- Space Shuttle Program Safety and Reliability Design Note - Hazardous Energy Sources
McDonnell Douglas Design Note No. I-EAST-S&R-6
- Advanced Missions Study - Volume II: Technical Discussion - Aerospace Corporation - ATR-72 (7316-01)-1
Volume II, Part 2 and Volume III, Part 2 - Contract No. NASw-2301
- Advanced Missions Safety - Volume II: Technical Discussion - Aerospace Corporation - ATR-72 (7316-01)-1
Volume III-2 - Contract No. NASw-2301
- Shuttle Orbiter Applications and Requirements (SOAR II)
Vol. XI, McDonnell Douglas, Contract No. NAS8-28583

3.2 APPLICABLE SAFETY CRITERIA FOR PAYLOADS

The safety criteria for the hazardous materials and systems uncovered in performing the current payloads safety analysis were grouped into the following:

- Radioisotope Thermoelectric Generator
- Electrical
- Pyrotechnics and Solid Propellant Motors
- Liquid/Gas Propulsion and Auxiliary Propulsion Systems
- Toxic Fluids/Gases

Pyrotechnics and solid propellant motors were grouped together because much of the initiating circuitry requirements is the same. For similar reasons, primary and auxiliary propulsion design and operational safety criteria are grouped together. A special section (Paragraphs 3.2.1 through 3.2.6) on the design and operational safety criteria for toxic fluids was deemed necessary because some propellants used in the main and auxiliary propulsion systems of the current payloads are toxic.

The applicable safety criteria for current payloads is specified in Section 4.0. An in-depth design analysis and trade study for each of these current payloads will be required to properly assess the degree to which the safety criteria should be implemented.

3.2.1 RTG Safety Criteria

3.2.1.1 RTG Design Criteria

- A redundant active RTG cooling system shall be provided within the Shuttle cargo bay to be operable on ascent and return/reentry and to be operable at the launch and landing sites with ground supplied coolant.
- Blast overpressure and fragmentation protection shall be adequate to ensure containment of all radioactive material in the event of an accident.
- Fireball protection shall be adequate to ensure containment of all radioactive material in the event of an accident.
- Redundant temperature control shall be provided for radioactive materials where such temperature control is required.
- The RTG design shall provide for safe (both normal and emergency) handling during ground or flight operations.
- Shielding shall be provided to reduce the exposure of the flight and ground crews and equipment to thermal and nuclear radiation from radioactive materials within RTG's.
- Fire alarms and other protection systems capable of supporting RTG's shall be provided during storage, testing, transportation, and at the launch pad.
- RTG systems shall provide a redundant and completely independent method for ground and flight monitoring to detect radiation leakage and assess thermal performance and pressures of the heat transfer loop.

- The largest practical physical separation between the RTG, the Orbiter cabin, and critical systems sensitive to radiation shall be provided.

3.2.1.2 RTG Operational Criteria

- Personnel assigned to work areas containing radioactive materials/devices shall not be routinely exposed to ionizing radiation in excess of the current KSC radiation protection standard KHB 1860.1/1S.
- Operations that at any time place the crew in the near vicinity of a radioactive heat source shall be avoided or at least limited.
- Certified operational plans to receive and store RTG's and check out power systems and components shall be provided.
- Quick retrieval operations to remove RTG's during an emergency shall be developed.
- Procedures for cooling the RTG's during all phases of the Shuttle ground operations shall be provided.
- RTG's shall be installed in the Shuttle cargo bay at the last practicable point in the launch countdown sequence.
- Ground crew training with confirmed procedures in the use of system monitoring equipment shall be provided.
- Suitable personnel exclusion area shall be provided at launch and landing sites.
- Emergency procedures and decisions (contingency plans) for emergency situations involving RTG hardware shall be established.
- Certified installation and removal equipment and procedures to handle RTG's shall be provided.

3.2.2 Electrical Safety Criteria

3.2.2.1 Electrical Design Criteria

- Payload battery cases shall be capable of withstanding internal overpressures in the worst case (i.e., terminal-to-terminal short with the relief valve closed) and pressure differences during Orbiter descent without rupturing.
- Payload batteries shall have the case vented through relief valves into the Orbiter overboard venting system.
- Payload circuits shall be designed with overload protection to prevent fires.
- Payloads shall have a means of shutting off their electrical power under emergency conditions.
- Payload electrical wiring must not be routed near sharp edges.
- Payload electrical wiring must not be in contact with flammable fluids or materials.
- Payload equipment containing high voltages must be designed to prevent electrical shock hazards.
- Electrical umbilical disconnects between the payload and the Orbiter shall be separated from hazardous-fluid disconnects, and shall be qualified as explosion proof.
- Payloads should be grounded to other cargo structures to prevent electrostatic charge buildup and an electrical shock hazard. Within the payload, grounding shall be such as to preclude an electrical shock. A positive ground shall exist from the payload to the Orbiter structure.

- Payload safety critical electrical and electronic components shall be potted, hermetically sealed, or similarly protected against the effects of liquid leakage, moisture, condensation, vibration, and arcing contacts.
- The return of current to the power source shall be accomplished by means other than the payload structure.
- Secondary power sources for safety critical payload functions shall be provided.
- Safety critical redundant payload electrical circuits shall not be routed through the same connector.
- Safety critical payload control circuits shall be capable of being verified.
- Positive identification and adequate protection from inadvertent operation shall be provided for safety critical payload switches. Identical safety critical switches shall not be located in close proximity to each other.
- Provisions shall be included for payload caution and warning functions that will provide both audible and visual warnings to the Orbiter crew to hazardous situations while the payload is aboard the Orbiter.
- Components containing mercury shall not be used for payload equipment to be installed in the Orbiter cabin. When used otherwise it shall be double contained.

3.2.2.2 Electrical Operational Criteria

- Inspection and test records of required safety device verifications and status inspections (of insulation material, etc.) shall be maintained.
- A record of payload equipment calibration, including test equipment and tools, shall be maintained.
- All payload lockout devices, warning signs and safety interlocks shall be deployed/activated before commencing operations involving electrical power capable of causing equipment damage or personnel injury.

- Initial power application and component functional tests shall be made following major maintenance and repair operations to payload equipment.
- Payload electrical equipment components and conductors shall be identified per the NEC or MIL standards, as appropriate.
- No equipment used to test payloads, including meters and tools, shall be used beyond calibration and test expiration dates.
- Payload ordnance material or ordnance igniting devices shall not be exposed to RF energy.
- Fueled payloads shall not be exposed to RF energy levels greater than 5 mW/cm^2 .
- Areas in which personnel are located shall not be exposed to RF energy levels greater than 10 mW/cm^2 .

3.2.3 Pyrotechnic and Solid Propellant Motors Safety Criteria

3.2.3.1 Pyrotechnic and Solid Propellant Motor Design Criteria

- The standard Manned Space Flight Initiator, which meets reliability and safety requirements for the Space Shuttle, or any initiator meeting the requirements of JSC 08060, Space Shuttle System Pyrotechnic Specification, or MIL STD 1512 shall be used on payloads.
- Payloads employing Exploding Bridgewires (EBW's) must include a dual bleed system for capacitor charge, a remote monitoring of capacitor charge status, and a positive means of interrupting the capacitor charging circuit and the trigger circuit.
- Safety critical payload pyrotechnic devices shall permit charge verification, e. g., neutron-ray inspection.
- Sequence logic and pyrotechnic firing circuits of the payload shall be capable of sustaining a failure without causing a hazard to the flight crew or damage to the Orbiter or other payloads. Payload pyrotechnic logic circuits shall receive power from a source other than the pyrotechnic batteries.

- To ensure firing of safety critical payload pyrotechnic devices in parallel, the design of pyrotechnic circuits must prevent constant power drain in the event that the device short circuits upon activation.
- Payload pyrotechnics shall meet the handling, installation, checkout, and operational requirements of Range Safety Manuals, AFETRM 127-1 and AFWTRM 127-1.
- Arming of payload pyrotechnic devices shall be protected against accidental operation.
- Payload pyrotechnic initiation circuits shall be routed separately from power circuits.
- Payload pyrotechnic firing circuits shall be protected from electrostatic-charge buildup.
- Payload pyrotechnic initiator electrical leads must be twisted, shielded pairs. This applies from the first safety open point beyond the power source to the ordnance item itself. There must be no electrical discontinuity or gaps in the shield, including continuity to the outer case.
- Safety design features, such as interlocks, redundancy, grounding, and isolation devices, shall be incorporated so that no single detectable failure or combination of undetectable failures shall result in premature detonation of explosive payload devices.
- Provisions shall be made for safing on command of unused explosive devices aboard the payload and safing verification sent to the Orbiter prior to retrieval.
- Payload safing devices should be located such that ground crews have easy access to them after the payload is installed in the Orbiter.
- Solid propellant motors shall be designed so that the primary initiating devices can be easily removed/installed at the launch site.
- Solid propellant motors shall utilize a safe and arm device as the controlled safing device.

3.2.3.2 Pyrotechnic and Solid Propellant Motors Operational Criteria

- Squibs, detonators, initiators, and other electro-explosive devices, when removed from standard packing, shall be transported in and remain in metal or metal-lined containers until actually installed in the payload.
- Nonconductive, static-producing materials shall not be used in the packaging of explosive components.
- Electro-Explosive Devices (EED) shall be properly shorted pin-to-pin and pin-to-case unless protected by a Faraday cage when shipped to the launch site.
- Packages containing explosives shall be marked in accordance with Interstate Commerce Commission (ICC) Regulation No. 15.
- Explosives shall be delivered to the launch complex or designated assembly area by authorized representatives of the launch support service contractor only after the concurrence of KSC Safety.
- Explosives shall not be handled when an electrical storm is imminent.
- Spark-proof tools shall be used when working with exposed propellants or explosives.
- All explosive materials used at the launch site shall be stored, inspected, and tested only in facilities designated and approved by the Safety Office. Explosives shall not be stored in (or delivered to) unauthorized areas.
- Work on explosive items shall be performed only in facilities specifically designated for that purpose.
- The EED's shall be installed as late in the countdown or prelaunch activities as is practical.
- Only essential personnel shall be present during EED installation and electrical connection.

- All space vehicle RF equipment shall be OFF before electrically connecting EED's.
- Before electrically connecting EED's, "no-voltage" checks shall be made, both pin-to-pin and pin-to-case.
- All employees shall wear conductive footwear (legstats are acceptable when used properly) and stand on grounded conductive surfaces while handling Category A devices.
- Electrical circuit test equipment used for testing explosive ordnance items, pyrotechnic devices, or circuits connected to these items prior to or after installation shall be approved by the Safety Office. Mechanical and electrical prints of the test equipment, with a brief description of their function, shall be submitted to the Safety Office for approval.
- Solid propellant motors (except for small solid propellant motors with built-in igniters) must not arrive at the launch site with the primary initiating device installed. Small solid propellant motors with built-in igniters must employ a means to ensure that premature ignition cannot occur.
- Solid propellant motors must not be shipped to the launch site with the grain exposed.
- Solid propellant motors used on payloads shall be adequately tested and assigned the appropriate hazard classifications prior to arrival at the launch site.

3.2.4 Liquid/Gas Propulsion Safety Criteria

3.2.4.1 Liquid/Gas Propulsion Design Criteria

- Payload propellant tank and pressure vessel design factors of safety shall be based either on overpressure or fracture mechanics and shall be at least as conservative as the design factors of safety called out. Fatigue criteria shall be based on life cycle requirements for individual payloads.

- Pressure vessels shall be fragmentation-proof, i. e., leak before burst, or be provided with fragmentation-proof container barriers. (If tank pressures during pre-launch through deployment operations are kept below the maximum operating pressure, these requirements may be relaxed appropriately.) Vessels and exterior pressure lines shall be clearly coded to identify content and operations pressure; this applies also to interior pressure lines that are accessible through access doors.
- Payloads shall not have structures that depend on tank pressure for structural stabilization where Shuttle damage could result if the tank pressurization were lost.
- Payloads must not generate forces, impulses or momentum changes that will produce adverse effects beyond the Orbiter GN&C capability while aboard the Orbiter or the IUS or Tug control capability (i. e., fluid sloshing in partly filled tanks).
- Payload leakage sources shall be minimized by use of all welded or brazed construction where practical.
- Payload cryogen tank thermal protection systems shall be designed to minimize (below ignition regimes) accumulation of flammable fluids resulting from propellant system leakage.
- To avoid formation of liquid air, the outer surfaces of payload cryogen tank systems that are exposed to the Orbiter payload bay environment on the ground or in the lower atmosphere shall be properly insulated and/or purged.
- Hazardous materials shall not be released or ejected into the payload bay from payloads. Venting, relief, and release of material from payloads shall be designed to use the Orbiter provided vent system. Control of the venting by the Orbiter for certain mission phases may be required. Relief of inert gases under some conditions may be permitted.
- A capability shall be provided for dumping liquid propellants of propulsion stages and relief of pressurants overboard through the Orbiter dump and vent systems. This shall be accomplished within the time constraints imposed by abort and shall be applicable with the payload doors open or closed.

- Relief/vent capability for payload pressurized tanks shall be provided to automatically limit maximum pressure. Relief/vent shall be to atmosphere unless gases/fumes are toxic or flammable. Relief/venting shall be designed to prevent mixing of mutually reactive fluids/gases.
- Capability shall be provided to monitor payload fluid and gas pressures and temperatures.
- No single operation shall result in flow of propellant through the payload propulsion system. The Auxiliary Propulsion System (APS) shall be inhibited while in the Orbiter payload bay.
- Interlocks shall be provided to prevent inadvertent operations of the payload while in the Orbiter payload bay or during the deployment phase of operation.
- Payload valve control events shall not be initiated by flight and crash landing loads.
- Payload propellant isolation valves shall be provided upstream from all start valves.
- Payload APS shall be capable of being shut down by one command from either ground or Orbiter control.
- Provisions shall be made to verify completion of main engine propulsion system safing prior to retrieval.
- Separate fill, drain, and vent lines distinctly marked and keyed shall be provided for the transfer of fuel and oxidizer. They shall be effectively isolated or separated by a sufficient distance to prevent mixing of reactant fluids.
- Payload propellant drain and vent interface with the Orbiter shall permit payload main propulsion system propellant venting, and emergency detanking (whether Orbiter is in horizontal or vertical attitude) with the Orbiter payload bay doors closed or open.

- Payload fluid fill, drain, and vent umbilical disconnects shall have positive sealing at disconnect, whether the action is intentional or accidental. Dual valving shall be provided to ensure emergency drain if one valve should fail.
- Flexible sections of high pressure payload gas lines and vent lines must be restrained to preclude a line rupture from producing line whipping with consequent damage to equipment or injury to personnel.

3.2.4.2 Liquid/Gas Propulsion Operational Criteria

- Payloads shall be received with redline limits for mission rules and procedures, including those applicable to emergency conditions that require payload jettison, hazardous fluids and pressurant dump, and hazardous system safing for mission abort.
- Mutually reactive fluids shall not be loaded into payloads or handled simultaneously.
- GSE to payload transfer lines shall be purged and cleaned following the transfer of hazardous fluids and before breaking of connections.
- Integrated checkout and testing of safety critical payload systems shall be conducted prior to integrating into a cargo and verified after installation into the Orbiter.
- Cleanliness requirements and fluid contamination for payload propellants and propellant systems shall be controlled and monitored.
- Payload shall not have APS and main engine pressurants onboard while being unloaded from or loaded in the Orbiter.
- Payload pressurized systems shall have a maximum operating pressure leak check before installation into the Orbiter payload bay.
- Propellant tank pressures, where practical, shall not be increased to operational values until deployment from the Orbiter.

- For pressure vessels designed using the factor of safety approach, personnel shall be evacuated for the first pressurization exceeding 25 percent of design burst pressure, subsequent pressurizations exceeding previous initial pressures, and any pressurization exceeding 50 percent of design burst pressure. Whenever pressure levels exceed 25 percent of design burst pressure in a vessel containing hazardous fluids (gaseous oxygen is excluded), the operation must be performed remotely. Design burst pressure values shall be based on the temperatures at which the pressure tests on the vessels will be conducted. A stabilization period of at least 5 min must be observed for all remote pressurizations before entry to the test area will be permitted.
- For pressure vessels designed using the fracture mechanics approach, personnel shall be evacuated for the first pressurization exceeding 50 percent of the operating pressure; subsequent pressurizations up to operating pressure can be performed without personnel evacuation at the discretion of the KSC Safety Office. A stabilization period of at least 5 min must be observed for all remote pressurizations before entry to the test area is permitted. In the event that the operating pressure must be exceeded, engineering analysis and appropriate test data must be submitted for approval of the Launch Operations Directorate and concurrence of the KSC Safety Office.
- For each payload pressure vessel, a log shall be established and kept current, recording its test history and exposure to various fluids. This log becomes a part of the data package for that particular payload.
- Pressure vessels and systems shall be exposed only to those fluids that have been demonstrated to be compatible with the vessel and system materials.

3.2.5 Toxic Fluids/Gases Operational Safety Criteria

- Hazardous material identification, including dosage limitations and precautionary measures required for handling, shall be posted in applicable areas.

- All payload personnel that will be near toxic materials when performing their jobs are required to satisfactorily complete the KSC safety training course applicable for the toxic material.
- A system for personnel access control shall be instituted for those areas where toxic materials are stored and/or used.
- Operations involving toxic chemicals shall not be performed by one man alone. Such operations shall be conducted by two or more personnel using the buddy system.
- Personnel engaged in handling and transferring toxic chemicals shall wear approved protective clothing and respiratory equipment.
- Emergency and personal protective equipment shall be placed in easily accessible locations.
- Protective equipment shall be kept where hazardous material is stored, handled, or used.
- Personnel shall be trained in the use of emergency protective equipment and procedures.
- Supervisors shall ensure that personnel are familiar with First Aid procedures for the specific hazards with which they are associated.
- Safety showers and eye-wash fountains shall be operable before any operation involving a toxic material begins.
- All containers of toxic chemicals shall be marked to indicate their contents. Where the attitude of a portable container is critical, it shall be marked to show the position to be maintained.
- Equipment and piping containing toxic materials shall be identified.

- Spills of toxic liquids shall be cleaned up immediately. Where necessary, decontamination shall be accomplished as soon as possible.
- Propellant systems shall be leak tested at the launch site before loading toxic and/or hazardous fluids and gases, unless acceptable certification is submitted.
- Propellant transfer lines, including double-walled lines, shall be drained and purged after the transfer of hazardous fluids and before breaking plumbing connections to preclude the escape of hazardous/toxic fluids/gases.
- The cleanliness of all propellants and materials/components in normal contact with the fluids/gases shall be controlled to prevent spontaneous decomposition/ignition in normal and emergency operational use.
- Mutually reactive fluids/gases shall not be transferred/loaded or handled simultaneously except when handled as a preloaded package/module.
- Tanking of highly toxic or cryogenic liquid propellants aboard a payload vehicle must be performed as late as possible during launch preparations.
- Water shall be available for decontamination of area and personnel.
- No spark or flame producing devices shall be permitted in propellant areas.
- Vapor sensors shall be operational.

3.2.6 General Safety Requirements

The following general safety criteria are applicable to all the hazardous current payloads.

- Payloads that contain radioactive materials or contain equipment that generates ionizing radiation shall be identified and approval obtained for their use. The initial description shall state source type, strength/quantity, containment/shielding, and chemical/physical form. Review will be implemented through the NASA center responsible for development of the

payload. In the event that a NASA center is not involved in the development, review will be implemented by the Safety Office of the STS operations organization. Major radioactive sources require approval by the Interagency Aerospace Nuclear Safety Review Panel through the NASA coordinator for the Panel. Reference to be used for isotope SNAP devices is NASA/AEC Interagency Agreement 1052.72A.

- Provisions against payload-generated hazards shall be provided for STS safety while the payload is near to or installed in any element of the STS and for personnel, equipment, and facility safety during ground operations. (In view of Shuttle's abort capability, expendable payloads are subject to this requirement through Orbiter landing and post-landing operations.)
- A safe interface between the STS elements, payloads, and GSE shall be maintained under nominal, contingency, and emergency operations of either the STS, GSE, or payloads. The interface during attached and/or detached operations shall be designed fail safe. At least two procedural operations shall be required for initiation of safety-critical functions. A mishap shall not result from any single procedural error.
- The capability shall be provided for redundant transmittal to the Orbiter Caution and Warning System that payload data are critical to the safety of the STS or its flight personnel. The redundancy may be accomplished via hardwires and/or via the Orbiter Performance Monitoring Function (PMF) and includes redundant sensors. The parameters to be transmitted and monitored will be identified by the user. Appropriate controls for safing the payload or operationally-required "command override" of safety-critical functions will also be identified by the user.
- Payload safety-critical data and control functions shall be capable of being tested for proper functioning from the Orbiter. This checkout may not include stimuli or calibration of sensor elements where complexities make this impractical.

- Safety-critical redundant equipment shall be separated to prevent hazard propagation to the maximum extent possible.
- The payload shall be designed, or protection provided, to preclude hazards to the flight personnel under crash-landing loads. (Crash-landing loads are defined in Space Shuttle Payload Accommodation Handbook.)
- Where hazards can occur because of the presence or contact of mutually-incompatible materials, such components or substances shall be separated to the maximum practical extent.
- To the maximum extent possible, flammable materials shall be separated to prevent flame propagation paths. Similarly, separation of flammable materials from possible ignition sources is required to the maximum extent possible.
- Hazardous materials shall not be released or ejected into the payload bay from payloads. Venting, relief, and release of material from payloads shall be designed to use the Orbiter-provided vent system. Control of the venting by the Orbiter for certain mission phases may be required. Relief of inert gases under some conditions may be permitted. A capability shall be provided for dumping liquid propellants of propulsion stages and relief of pressurants overboard through the Orbiter dump and vent systems. This shall be accomplished within the time constraints imposed by abort and shall be applicable with the payload doors open or closed.
- Use of stress-corrosion-susceptible materials in payload mounting or support bracketry should be avoided to minimize possible safety hazards created by structural failure of these elements.
- Pressure vessels shall be in accordance with NASA Aerospace Pressure Vessel Safety Standard NSS HP 1740, 1 or in accordance with ASME Boiler and Pressure Vessel Code.

- Prior to installation of any payload safety-critical equipment into the Orbiter, the equipment shall have been satisfactorily verified for the expected operational regimes. Analysis and/or test are two techniques for such verification.
- Payloads that have flown on previous flights shall be verified for:
 - Correction of any safety deficiency encountered on previous missions
 - Safety impact of any changes made to the hardware or operation procedures.
 - Any maintenance and/or refurbishment affecting safety.
 - Appropriate design features for reuse or reflying.
- Payload design and operations shall not impose restrictions on normal or contingent Space Shuttle operations (including intact abort and rescue operations) in which the safety of the STS or flight personnel may be affected.
- Contingency safety planning (emergency or backout procedures) for ground or flight anomalies involving Shuttle payloads shall be developed.
- Destruct systems shall not be used on the current payloads identified by this task when flown on the Shuttle Orbiter.
- All safety-critical command and control circuitry associated with engine firing, primary propulsion systems, or auxiliary propulsion systems shall be designed to be fail operational/fail safe to preclude inadvertent firings in case of initial hardware failures.
- Any hardware that is deployed in orbit past the Payload Bay doors mold line shall have a redundant retraction or a jettison capability that can be initiated from pressurized compartments (not requiring EVA).

- Reusable payloads shall include provisions to permit preretrieval safing to be verified by the Orbiter flight crew prior to the conduct of retrieval operations.

4.0 RECOMMENDED SAFETY CRITERIA FOR CURRENT PAYLOADS

Each payload classified as a current payload in paragraph 2.1 was analyzed to determine its hazardous materials and systems and then matched to the applicable safety criteria presented in paragraph 3.2. A summary of the findings is covered in the following current payload hazard and safety criteria charts. A chart is included for each current payload. The data on these charts identify the hazard source, material, and system function that induces the hazard. The applicable safety criteria for each hazard source are specified by paragraph number.

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CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Extra Coronal Lyman Alpha Explorer (AS-02-A)

SCIENTIFIC DISCIPLINE: Astronomy

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
High Pressure	GN ₂ - 90.7 kg	Provides propulsion for orbit altitude maintenance and station keeping	3.2.4.1 & 3.2.4.2
High Pressure	GN ₂ - 22.6 kg	Provides thrust for attitude control and momentum dumping	3.2.4.1 & 3.2.4.2
Electrical	610 W max., 100 W dc standby	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2
Fire/Explosive	Battery	Electrical Power	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Cosmic Background Explorer (AS-03-A)

SCIENTIFIC DISCIPLINE: Astronomy

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
High Pressure	GN ₂ - 90.7 kg	Provides propulsion for orbit altitude maintenance and station keeping	3.2.4.1 & 3.2.4.2
High Pressure	GN ₂ - 22.6 kg	Provides thrust for attitude control and momentum dumping	3.2.4.1 & 3.2.4.2
Electrical	610 W max., 110 W dc standby	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Cryogenic	LHe (TBD)	The telescope equipment requires cryogenic cooling	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Electrical Power	3.2.2.1 & 3.2.2.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Advanced Synchronous Meteorological Satellite (EO-07-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Hypergolic	Hydrazine - 89 kg	Provides propellant for attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine attitude control system	3.2.4.1 & 3.2.4.2
Electrical	360 Vac	Electrical systems/equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Earth Observatory Satellite (EO-08-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Fire/Explosive	Solid Propellant 453.6 kg	5 vm--2 model rocket engines serve as kick motor for transfer from Shuttle orbit to mission orbit	3.2.3.1 & 3.2.3.2
Hypergolic	Hydrazine - 68 kg	Provides propulsion for orbit adjust capability	3.2.4.1, 3.2.4.2, & 3.2.5
Fire/Explosive	Pyrotechnics	Pyroactuated devices are required for Solar Array Deployment and Solid Propellant Igniters	3.2.3.1 & 3.2.3.2
High Pressure	GN ₂	Provides pressurization for hydrazine orbit adjust propulsion system	3.2.4.1 & 3.2.4.2
Electrical	4000 W max., 30 W dc min.	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Applications Explorer (Special Purpose Satellite) (EO-10-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Hypergolic	Hydrazine - 19 kg	Provides propulsion for attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine attitude control system	3.2.4.1 & 3.2.4.2
Electrical	90 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: TIROS 'O' (EO-12-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Hypergolic	Hydrazine	Provides propulsion for orbit injection correction	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine propulsion system	3.2.4.1 & 3.2.4.2
High Pressure	GN ₂	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Electrical	350 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Environmental Monitoring Satellite (EO-56-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	589 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 12.45 kg	Provides propulsion for orbit injection correc- tion	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressuriza- tion for hydrazine propulsion system	3.2.4.1 & 3.2.4.2
High Pressure	GN ₂	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2
Fire/Explosive	Battery	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Foreign Synchronous Meteorological Satellite (EO-57-A)

SCIENTIFIC DISCIPLINE:

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	140 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 15.9 kg	Provides thrust for attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Battery	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Geosynchronous Operational Meteorological Satellite (EO-58-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	140 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 15.9 kg	Provides thrust for attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine and attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Earth Resources Survey Operational Satellite (EO-61-A)

SCIENTIFIC DISCIPLINE: Earth Observations

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	550 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 14.5 kg	Provides thrust for orbit adjust capability	3.2.4.1, 3.2.4.1, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine propulsion system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: GEOPAUSE (OP-01-A)

SCIENTIFIC DISCIPLINE: Earth and Ocean Physics

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	410 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
High Pressure	GN ₂ - 115.6 kg	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Gravity Gradiometer (OP-02-A)

SCIENTIFIC DISCIPLINE: Earth and Ocean Physics

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	163 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
High Pressure	GN ₂ - 847 kg	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Mini-LAGEOS (OP-03-A)

SCIENTIFIC DISCIPLINE: Earth and Ocean Physics

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Non-Hazardous			

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: SEASAT-B (OP-07-A)

SCIENTIFIC DISCIPLINE: Earth and Ocean Physics

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	620 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Pioneer Saturn Probe (PL-22-A)

SCIENTIFIC DISCIPLINE: Planetary

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	TBD	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Radiological	Plutonium 238	RTG's	3.2.1.1 & 3.2.1.2
Hypergolic	Hydrazine - 52.4 kg	Provides thrust for propulsion and attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
Fire/Explosive	Pyrotechnic	Various pyroactuated devices	3.2.3.1 & 3.2.3.2
High Pressure	GN ₂	Provides pressurization for hydrazine propulsion system	3.2.4.1 & 3.2.4.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: INTERSAT (CN-51-A)

SCIENTIFIC DISCIPLINE: Communications/Navigation

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	4400 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine	Provides thrust for propulsion system	3.2.4.1, 3.2.4.2, & 3.2.5
Fire/Explosive	Cesium Ion	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Pyrotechnics	Various pyroactuated devices, Solar	3.2.3.1 & 3.2.3.2
High Pressure	GN ₂	Provides pressurization for the hydrazine propulsion system and cesium ion system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Battery	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: U.S. DOMSAT 'A' and 'B' (CN-52-A and CN-53-A)

SCIENTIFIC DISCIPLINE: Communications/Navigation

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	4400 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine	Provides thrust for propulsion system	3.2.4.1, 3.2.4.2, & 3.2.5
Fire/Explosive	Cesium Ion	Provides thrust for attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Pyrotechnics	Various pyroactuated devices, solar array deployment	3.2.3.1 & 3.2.3.2
High Pressure	GN ₂	Provides pressurization for the attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Battery	Power storage	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Traffic Management Satellite (CN-55-A)

SCIENTIFIC DISCIPLINE: Communications/Navigation

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	1100 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine	Provides thrust for propulsion and attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine and propulsion system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Power storage	3.2.2.1 & 3.2.2.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2
High Temperature	Heaters	ECS	3.2.2.1 & 3.2.2.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: Foreign Communications Satellite A (CN-56-A)

SCIENTIFIC DISCIPLINE: Communications/Navigation

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	514 W	Electrical system/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 58.1 kg	Provides thrust for propulsion and attitude control systems	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine, propulsion system, and APS system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Batteries	Power storage	3.2.3.1 & 3.2.3.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2

CURRENT PAYLOAD HAZARDS AND SAFETY CRITERIA

PAYLOAD DESIGNATION: U. S. DOMSAT 'C' (CN-58-A)

SCIENTIFIC DISCIPLINE: Communication/Navigation

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM / FUNCTION	APPLICABLE SAFETY CRITERIA
Electrical	716 W	Electrical systems/ equipment test and checkout	3.2.2.1 & 3.2.2.2
Hypergolic	Hydrazine - 25.1 kg	Provides thrust for attitude control system	3.2.4.1, 3.2.4.2, & 3.2.5
High Pressure	GN ₂	Provides pressurization for hydrazine attitude control system	3.2.4.1 & 3.2.4.2
Fire/Explosive	Pyrotechnics	Solar Array Deployment	3.2.3.1 & 3.2.3.2